

ART. IV.—*An Essay on the Classification of Nemertes and Planariæ: Preceded by some general considerations on the primary Divisions of the Animal Kingdom*; by CHARLES GIRARD.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

I.

I AM gathering materials for a monograph of the Nemertes of this side of the Atlantic. I have already said on another occasion that I was doing the same with regard to the Planariæ. It will not be anticipating the final results of these investigations to present here some general considerations respecting the place that may conveniently be assigned to these animals in our zoological system.

The chronological history and the position that the various authors have assigned to the Nemertes and Planariæ having been fully brought out by Mr. de Quatrefages,* I shall not dwell upon that part of the subject.

The question now under consideration bearing merely upon the fundamental groups of the animal kingdom, I need only go back to Cuvier, since he established these groups and since the foundations of our classification are the results of his labors.

Nor shall I at present enter upon the secondary divisions to be established among the Nemertes and Planariæ; this aspect of the question cannot be settled until we are better acquainted with the organization of the group of Rhabdocœla or freshwater Planariæ.

II.

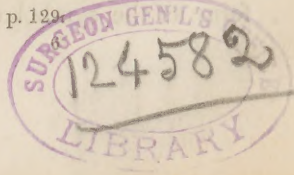
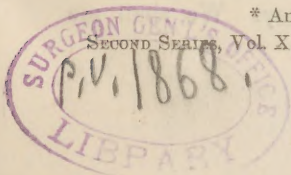
Before however I treat of the Nemertes and of the Planariæ in a more particular manner, I have a few words to say on the subordination of characters in the primary groups of the animal kingdom.

There are in the animal kingdom but two main systems of organs to which all the others are related, being in a word, mere dependences or branches of them. These two systems of organs are: 1. the *nutritive system* or *system of vegetative life*, and 2. the *sensitive system* or *system of animal life*.

Now which of these two systems of organs is the most important; in other words, which ranks highest as a zoological character. The nervous system, some physiologists will answer. But let us examine this point. What is the distinguishing character of the animal kingdom as a kingdom? A digestive cavity of some kind, into which are introduced nutrient substances neces-

* Ann. Sc. Nat., 3d Série, iv, 1845, p. 129.

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sary for the maintenance of living bodies; necessary to their growth anterior to the period of full development and to their equilibrium after having reached their complete size. The digestive system then is the universal character, common to all animals, and this character gives us the animal kingdom: it ranks then highest.

Next to the entire animal kingdom we have the four great primary divisions, the division of Vertebrata, the division of Articulata, the division of Mollusca and the division of Radiata, and these four divisions are characterized by the nervous system chiefly. The plan of structure of the nervous or sensitive system giving these divisions and these divisions exclusively, its importance is of a secondary degree. For the nervous system has not yet been materially demonstrated in all the Radiata, whilst the nutritive system is to be seen everywhere. Not that I deny the sensitive system to any animal even where it has not been shown. There exists among the lower Radiata a homogeneity of substance which is perhaps the only obstacle to its discernment; nevertheless the digestive system being everywhere distinct, this latter must have the preëminence.

It has the preëminence because it gives us the unity of the kingdom as we have also this unity in the perfect resemblance of all eggs at an early period of their history. In the animal the first substance which is formed is the vitellus or yolk; it is the foundation of the future being, it is, as Prof. Agassiz has observed, the being itself. Out of the yolk the nervous system originates as well as all other parts of the organism, so that in an embryological point of view the nervous system holds a second rank.

It is of secondary rank as a material organ and character of classification of animals. It plays the highest part by its immaterial essence in the human species. But here we leave the boundary of the animal kingdom and therefore the classification, which is our object, to enter another kingdom, the kingdom of Thought.

The nutritive system being the index of animality we see all animals equally compelled to take food; this is the essential condition of their existence.

The nervous system being the fundamental basis of the primary divisions, it gives to each division a special immaterial tendency so long taught by Prof. Agassiz. Now as there are four divisions there are also four of these tendencies. And as soon as there are four immaterial tendencies, there is an antagonism amongst them. This is a natural consequence since the nervous system overrules the division and its dominion is of a spiritual character.

The nervous system stamps upon the divisions their zoological form as the symbol of their diverse tendency. We shall see

further an *apparent* anomaly of this kind in the beings placed at the boundaries of two divisions where the material form, to use the words of Milne Edwards, escapes the supremacy of the nervous system. The principle however remains always the remote cause.

Besides the antagonism of the divisions between themselves, there is an antagonism between the instinct and the intellect, that is to say, three of the divisions against the fourth: the Articulata, the Mollusca and the Radiata, collectively known under the appellation of invertebrate animals, all of which have only instincts, against the Vertebrata which possess, beside instincts, intelligence to a certain degree.

Now between the invertebrate animals and the vertebrata the struggle is latent, passive, because the two principles, the instinct and the intellect, do not coexist. But among Vertebrata where we find both the instincts and the intellect in the same individual, the struggle is active and direct, and we are indebted to the observations of Fred. Cuvier, for the revelation of this astonishing law, that wherever the instincts command, the intellect is actionless, and wherever the intellect governs, the instincts are silenced or nearly so. There is a struggle and an open struggle; the victory of one of the principles involves the subjection of the other.

Morally speaking, we might thus establish two series in the animal kingdom; an instinctive series, stationary and sightless, and an intellectual series, progressive and seeing; the first including three divisions, (Radiata, Mollusca, Articulata,) and the second only one (Vertebrata).

And now, if we go back to the origin of the animal kingdom, and trace its history in the past, we see the two series appearing simultaneously from the first manifestation of life upon the surface of the earth: the instinctive series with its three divisions and all the classes; while the intellectual series is represented by one class only, that of fishes.

Their forms are renewed during a succession of periods and each great revolution of the globe adds one class to the division of Vertebrata or the intellectual series, in the order of their zoological gradation: Reptiles, Birds and Mammals:—then Man crowning the whole work. Thus a real progress is manifested in the division of Vertebrata while the Invertebrate animals remain what they were, although undergoing a renewal of forms. The reason of this is, as Fred. Cuvier states, that the instinct is innate, always sightless, necessary and unchangeable, whilst the intellect is progressive, conditional and susceptible of modifications.*

* Flourens. *Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux.* Paris, 1844.

In the intellectual series there was an aim, a design, and this was, to arrive at man, the true domain of intelligence. This aim realized, the creation would stop and it did stop. Zoological forms had acquired all that diversity with which the sphere of activity of each division was endowed. To the immaterial principles nothing was left except a limited play, a contest for supremacy. To intelligence alone was given the power to arrive at the knowledge of the actual world, to look back in time, to contemplate itself in the past in view of the future, finally to study itself,—in a word, to *reflect*.*

The power of reflection belongs exclusively to man, the last being created. Man being the converging point of the material creation, in him were also to be concentrated in our time the struggles of the two spiritual principles of all past time.

One word more on the intellectual series. The fishes, reptiles, birds and mammals belong to this series, but the fishes, the reptiles, the birds and most of the mammals in their natural condition of life have no intelligence,—have no intellect.

The intellect resides within the brain, and the vertebrata alone have a true brain. The brain is composed of several parts. There is the base of the brain which sends nerves to the organs of sense, and the hemispheres, the special seat of the intellect. Now of the hemispheres the fishes have only a rudiment, and this is the reason why they have no intellect. There exists a well defined progression from the fishes to the mammals with respect to the development of the hemispheres; placed anteriorly in the fishes, they rise degree by degree in the other classes over the base which is gradually covered and concealed under them. Here we see the organ reflected upon itself, reminding us of its function in its full activity, reflection. To this gradual development corresponds a position of the head more and more raised which becomes vertical in man,—where it forms a right angle with that of fishes. One step more would have been retrograde: the development there stopped.

Thus by a gradation almost imperceptible we have beings belonging to the intellectual series which have the intellect only in a virtual state. They have the organ without having the principle, or at least admitting the principle virtually present, the organ is not sufficiently developed to allow its manifestation.

These general considerations, although a brief résumé, will perhaps appear out of place in this paper; but my object is the discussion of the value of the nervous system as a zoological character, and to show that while this system of organs gives only the divisions, these latter are governed by it in an absolute manner.

I now come to the special topic of my communication.

* Flourens. *Resumé des travaux de F. Cuvier, sur l'instinct et l'intelligence des animaux*. Paris, 1844.

III.

The place assigned by Cuvier to the Nemertes and to the Planariæ in his "Animal Kingdom," is entirely provisional as acknowledged by the illustrious naturalist himself.

The Nemertes are placed in the division of Radiata immediately after the *Intestina cavitaria*.

Between Nemertes and the intestinal worms of this order there are only analogies. The extraordinary length of the body of some of them, for instance *N. Borlasii* (*Borlasia angliæ*), a length reminding us of the class of worms, and above all of some of the intestinals, such as the tape worm, had prevailed over all other considerations. Their affinities were not acknowledged because their organization was unknown.

At that time the intestinal worms were regarded as Radiata, for the reason that their nervous system had not been found, and the Nemertes, as well as Planariæ, were regarded as intestinal worms because all of them reminded us by their forms, of the forms of these last.

When the more recent labors of some zoologists had established beyond any doubt that the intestinal worms belonged to the division of Articulata, on account, first, of their having a nervous system, and a nervous system constructed on the plan of that group, secondly, by the structure of their body, which is composed of a series of articulations or rings movable upon each other, then the Nemertes were carried with the *Intestina cavitaria* into the division of Articulata where they remained as little known as before. It is but of late that they have been made the subject of a special study by a skillful zoologist, Mr. de Quatrefages, and I am surprised that this author has not pointed out the close affinities which they bear to Mollusca.

Cuvier was well aware of the space which separated Nemertes from intestinal worms, inasmuch as he foretold that they would one day constitute a new order. In spite of these external resemblances, their structure which as he says "*is of an extreme softness*," caused him to doubt. Nevertheless it did not, on this account, enter into his mind to compare them with Molluscs.

At that time, as indeed now, the idea of a mollusc corresponded with the idea of a shell-bearing animal, with the form of a body more or less drawn together into itself, while the lengthening of the body involved by analogy the idea of a worm.

Now if abstracting the form, which is not the characteristic of the divisions, we look at the intimate structure, if we give up also the shell as circumscribing the division of Mollusca, we shall find in the Nemertes all the principal characters of Molluscs: a soft body, entirely smooth, covered with a glutinous mucosity; a very simple nervous system reduced to a small number of cephalic

ganglia, whence nervous threads depart to distribute themselves in the body. If we further state that, as in the greater number of Molluscs, the surface of the body is covered with vibratory ciliæ which help their movements, movements generally slow, deprived of energy, then we directly arrive at the idea that Nemertes are really Molluscs,—Molluscs of a low rank, being parallel with the worms of the division of Articulata by the analogy of their forms.

Having discussed above the value of the nervous system as the predominant character of the *division*, exclusively of any other character, it remains only for me to state that the nervous system of Nemertes is constructed upon the plan of the nervous system of Molluscs: there exists a cephalic mass more or less lobed, representing either the superior œsophageal ganglion of other Molluscs, or that same ganglion to which, on account of the peculiar form of the body, are added the two or three abdominal ganglia. Nervous threads are distributed in all directions; two of them more voluminous than the rest, but uniform in structure, run along the sides of the animal, and sending off thinner threads without showing in their course those ganglia or swellings which distinguish the nervous system of Articulata, such as it is in Malacobdella, Peripates, &c.

The disposition of the nervous system of Nemertes, then, is merely *analogous* to that of Annelids; its structure is that of the nervous system of Molluscs.

IV.

The position of Planariæ in the division of Radiata is not less curious than that of Nemertes. Included in the second order of intestinal worms, the *Parenchymata*, they are brought near the Trematodes, to which they have only analogies, in the same sense as those that Nemertes have to the *Intestina cavitaria*.

The *Intestina parenchymata* have been withdrawn from the division of Radiata and brought into that of Articulata, and for the same reasons as that of the *cavitaria*. The Planariæ, of course, have thus been compelled to follow them in the same manner as Nemertes have followed the latter. But also little investigated at that time, their affinities with Molluscs have escaped the eyes of zoologists.

The Planariæ are not parasitical as Trematodes are, and it is important that this fact should be noted, parasitism existing most extensively among Articulata. The investigations of Mr. de Quatrefages and others have moreover made us acquainted with their structure which, although not yet entirely understood, as I believe, is however of the highest interest. Indeed in Distoma the digestive system is constructed upon an analogous plan with that of Planaria; but the digestive system, as we have said, can-

not characterize the primary *division*. It gives but the ~~subordi-~~ / *Ki*
~~nate grouping.~~

As soon as it is acknowledged that the *division* rests upon the structure of the nervous system, the fact that the nervous system of Distoma is that of Articulata, and the nervous system of Planariæ is that of Mollusca, there is no ground for further hesitation.

In Distoma there are two cephalic ganglia, whence nervous threads part for the anterior region of the body. From each one of these ganglia arises a nervous thread which takes its course backwards; this thread presents on its length a series of small ganglia, scarcely distinguishable upon the middle region, it is true; but very apparent towards the posterior region, where they are seen sending off smaller threads distributing them to the body. This arrangement of the nervous system of Distoma becomes especially distinct in Malacobdella where the same arrangement is found, with the ganglia of the lateral threads more developed. Thus, taking the nervous system into consideration, Malacobdella is one degree higher than Distoma, then Clepsine would follow in which the two threads are brought so close together that they combine into one single thread. Above Clepsine would rank the other Hirudines.

In Planariæ we have a cephalic ganglion more or less lobed on its circumference which sends nervous threads to all the regions. There are two more voluminous lateral ones (one on each side of the body) as in Distoma, but uniform as in Nemertes, still recalling here by analogy the nervous system of Articulata. The fundamental difference, although less apparent at first sight, consists in the absence of ganglia upon their lengths, and this fact decides all.

The body of Distoma, indeed, is not articulated and this may perhaps lead to a belief of a closer affinity between Planariæ and worms. Their broad and flattened form would be better adapted to their mode of life without that structure. Moreover the articulation of the body, although a character of the division, is subordinate to the nervous system. Consequently there is no ground for surprise at seeing it vanish or even entirely disappear in those groups placed at the boundaries of two divisions as a material property in litigation, disputed by antipathic vital tendencies, each endeavoring to appropriate it to itself.

Considering now the softness of Planariæ, that glutinous mucosity which surrounds them, that body of a uniform shape without articulations and deprived of articulated limbs, that general apathy, all these are so many characters which they partake with Mollusca and do not partake with Articulata.

However, I do not know that any one has proposed to consider these animals / Molluscs, although Baer and Dugès had already compared the inferior disk of Planariæ to the foot of Gas- / *a*

teropoda without thinking of bringing them together in the same natural group. Mr. de Quatrefages refutes this comparison. We shall come to it again presently.

For, if the shell does not characterize Mollusca, inasmuch as all living Cephalopoda are naked, and among Gasteropoda we have the whole group of Nudibranchiata deprived of a shell, that of Pteropoda, and among Acephala that of Tunicata, it requires no effort of imagination to admit in that division, animals such as Planariæ. They are flattened Molluscs in the same manner as Nemertes, are elongated or stretched Molluscs, as are also Dentatium, which nobody would place elsewhere than among Molluscs.

Many authors have spoken of the organization of Planariæ, from Dugès to MM. de Quatrefages and Blanchard. All have viewed them as worms, doubtless prepossessed by the idea that Cuvier who had established the divisions could not have been mistaken so far as to place side by side in the same order animals belonging to two different divisions.

But this error of the author of the "Animal Kingdom" is easily accounted for. At that time he was in want of the essential datum to settle such a question in its details, the knowledge of the nervous system.

The plan of structure of the nervous system, we have already said, and we cannot repeat it too often, gives only the division and nothing but the division. Now Cuvier did not know it when he laid the foundation of his classification; although he foresaw the four plans of organization of the whole kingdom; and as he said there are but four of these plans.

He who has done most after Cuvier to establish the doctrine of these four plans of organization, is Prof. Agassiz. He has the unquestionable merit of having followed out the traces of these plans beyond the existing creation, and in ascending through past ages of the world's history he has been enabled to reconstruct the biological phases to which I have alluded above. In reading the history of the earth on the strata which compose its crust as so many pages of a book written by the hand of the Creator, we then find again the thought of these four plans of organization preconceived by Cuvier, demonstrated as a doctrine by Prof. Agassiz.

These four plans of organization would acquire a far greater importance if embryology should ratify them. Now embryology does so. All embryological investigations past and contemporaneous lead towards four plans of structure. I shall not treat of this question more in detail here; it is sufficient merely to mention the fact.

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Now the question respecting the class among Molluscs to which Planariæ belong is easily settled. They crawl on the inferior

surface of their body; that they are Gasteropods, there can be no doubt. Do we not see them, as well as Pulmonata, Nudibranchiata and others, creeping along the walls of a basin and when near the surface of the water, reversing their position and walking in that manner with the same facility? Do we not witness the same undulatory contractions in that foot? Therefore were not Baer and Dugès guided aright when they compared the inferior surface of the body of Planariæ to the foot of Gasteropods?

I am not aware that any of the Planariæ I have studied moves with the same facility on the back as on the belly as Mr. de Quatrefages states. Whenever I placed them in that position I always saw them changing it as quickly as possible. Besides in most cases I have seen the upper surface differing widely from the inferior one.

In Planocera we have on the dorsal surface two cylindric tentacles, analogous to the cephalic tentacles of Doridians. In Thyzozoon or Eolidicera, the cephalic tentacles are flattened and are brought entirely forwards while other tentacles appear on the back, reminding us of the dorsal appendages of Eolidians proper. Then come Proceros and Procerodes with but the flattened anterior tentacles of Eolidicera and in the same place as in these last.

There exist then in the marine Planariæ one group which reminds us of Doris, another of Eolis, and still another group intermediate between Eolis and Planaria proper which lead to the freshwater species.

This shows that it is near Nudibranchiata that Planariæ will find a natural place, and on several accounts we should be tempted to consider them as a degradation of that type.

But for us who do not admit the so-called degradations, inasmuch as each being appears to us as to Cuvier, *a perfect whole by itself*, we consider Planariæ as a family nearly allied to that of Nudibranchiata, bearing in itself the reason of its existence as strongly defined as this latter, and representing merely a variation in the thought of the Creator.

For, in Nudibranchiata we find a number of types all as much diversified. These are: *Doridians*, *Eolidians*, then *Canthopsis* analogous to *Procerodes* which leads to the *Acteonians*, then finally the genera *Pelta* and *Chalidis* which constitute another group almost Planarian, deprived of external appendages of any kind.

There exists a striking parallelism between the zoological forms of these two families.

Viewed in the light of their organization nothing is more alike. The nervous and digestive systems scarcely differ. I have already spoken of the first. With regard to the second I shall recall the fact that it is ramified in Nudibranchiata as in Planariæ; the ramifications being diversified according to the groups.

The organs of generation do not differ much more. Nudi-branchiata are androgynous like Planariæ. The fecundation takes place by mutual fecundation as is the case in Pulmonata. But in Planariæ we have cases where an individual fecundates itself, the hermaphroditism being here complete.

V.

It still remains for me to make some general remarks upon Nemertes and Planariæ.

Mr. de Quatrefages tells us himself, "neither Nemertes nor Planariæ have externally a resistant and tough layer, similar to that which is found with Annelids, for example, or even with Rotatoria."⁷*

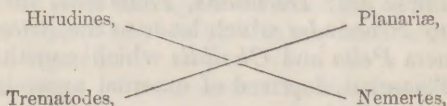
We have then two groups of Gasteropodous molluscs parallel with two groups of annulated Articulata; the group of Planariæ reminding us of Helminthes, and the group of Nemertes reminding us of the Hirudines.

At the extremes of these two groups, at the bottom of the two classes, we witness in some sort a strange and opposed struggle of the two immaterial principles of the divisions which exert themselves to take from each other some portion of their material property. As examples we have:

In Molluscs,—the Nemertes which elongate and become worm-like; the Planariæ which remain shorter but pressed down, spread out, flattened in thin leaves.

In Articulata,—the softness of Helminthes in general, the flattening of their body in Trematodes in which the articulation of the body vanishes, analogous to Planariæ;—the softness still of the Leeches with a distinct articulated structure, being parallel with Nemertes.

These groups do not oppose each other in an exact parallelism, for Nemertes which form a low type of Gasteropods are opposed to the Leeches of a higher grade of worms, and Planariæ a higher grade among Gasteropods are opposed to Trematodes a lower type among worms. In this manner:



In the elongation of the body of Nemertes there is nothing to surprise us. Placed at the bottom of the class to which they belong, they assume a form analogous to a group of the division of Articulata which attract them but to which they do not belong. Now when a Mollusc, whose body is elongated beyond all pro-

* Ann. Sc. Nat., 3d series, vol. iv, 1845.

portion, and obliged sometimes to move by the contraction of transverse muscular fibres, accelerates its progress, then we see that Mollusc assuming certain transverse, irregular and unequal folds,—shadows of articulations which in reality do not exist.

At the bottom of the division of Articulata we observe similar facts. The Trematodes lose insensibly that elongated form of the body which constitutes the prominent character of the worms; they are flattened, spread out, meanwhile the articulation of the body, the characteristic of their type, vanishes completely,—thus foreshadowing the type of Planariæ.

The position and number of eye-specks in Nemertes and Planariæ indicate also a greater resemblance to the same organs in Molluscs than to those of Annelids. When eyes exist in Annelids, they are arranged in pairs on both sides of each articulation or else form a crown on one of the anterior rings. In Planariæ we find the eye-specks irregularly grouped on the upper surface near the anterior region of the body. The same arrangement is observed in Nemertes. This arrangement forcibly reminds us of what we see in Gasteropods. In Planariæ alone they are more numerous and distributed with less constancy, a fact which is accounted for by the lower position of that family in the class.

The habits of Nemertes and Planariæ speak rather in favor of Molluscs than worms. Most of them live concealed under stones which is the case with many Molluscs, while I do not know any which lives within a tube constructed like those of worms.

The embryonic development of both Nemertes and Planariæ takes place according to the laws we witness among Gasteropods. The larval condition of both Gasteropods and Planariæ is very similar.

It is plain enough, Nemertes and Planariæ are only *analogous* to Articulata; by their *affinities* they are Molluscs. The division of Articulata hence appears to us as a type more natural and rational, as well as that of Mollusca; this latter including all animals which are soft, slimy and flabby, whatever may be their form.

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The Rhabdocœlæ or freshwater Planariæ will be the connecting link by which the Nemertes approach Planariæ proper, as members of the same group. We may say of them that they are the freshwater representatives of both Nemertes and Planariæ. And now observe the transition: the group, Rhabdocœlæ, which is distinguished at once from Planariæ and Nemertes, this group, I repeat, lives in fresh waters, while the other two groups which they connect together are scarcely found beyond the boundaries of the seas. If some of them ascend the rivers it is within the limits where the water still retains a part of its marine character.

So that the connection although materially expressed, exists essentially in their immaterial essence.

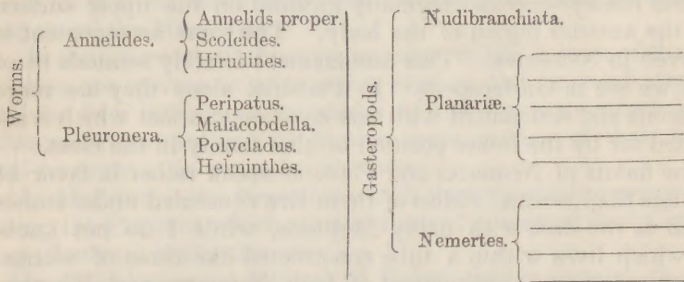
VI.

I now conclude by a few words on Annelids and Gasteropods.

Having withdrawn from the first of these classes a certain number of its representatives to include them among the second, it is to be expected that I should present in a synoptical manner the systematic modifications resulting from it.

If we admit the two sections of worms proposed by Milne Edwards, the Pleuronera and Annelids proper, we should place them one above the other to form a single series instead of one.

Opposite we should have the series of Gasteropods beginning with Nemertes; above these the Planariæ, then the Nudibranchiata;



What would come next to the Nudibranchiata I am not prepared to say. The series cannot go on, on that footing, for the very simple reason that embryology assigns a lower rank to all Gasteropods provided with a shell, inasmuch as Nudibranchiata, when hatched, have a shell, which they lose at an early period of their life. The attempt at forming organic series in the animal kingdom is one of the most difficult of labors, and a work of a relative value. Unless several series are established in the class of Gasteropoda, the position of Nudibranchiata in the above synopsis cannot be accounted for. I have already made the remark that Planariæ were rather parallel to Nudibranchiata than of a lower rank, finding in these two families groups of equal importance.

Respecting the serial arrangement of worms, as given above, and resting upon the morphology of their nervous system, I have also to remark, that it does not coincide with another series alluded to in a remarkable paper of late publication;* and indeed if lumbricine Annelids and Leeches are higher in their class, as I be-

*The natural relations between Animals and the Elements in which they live; by Prof. L. Agassiz. This Journal, 2d ser., vol. ix, p. 369.

lieve it, this fact corroborates the idea that the nervous system characterizes only the primary divisions. And our position would turn out to be the right one.

If instead of a single series, or several series with a starting point and an end, we construct a circle or an ellipse, and place the Gasteropods on its circumference, then the arrangement of each group would meet with less difficulty and perhaps satisfy completely the mind.

Cambridge, Mass., October, 1850.

